RS-002, "PROCESSING APPLICATIONS FOR EARLY SITE PERMITS"

ATTACHMENT 2

2.5.5 STABILITY OF SLOPES

REVIEW RESPONSIBILITIES

Primary - Mechanical and Civil Engineering Branch (EMEB)

Secondary - None

I. AREAS OF REVIEW

Information, including analyses and substantiation, should be presented in the applicant's site safety assessment for an early site permit (ESP) and reviewed by the staff concerning the stability of all earth and rock slopes both natural and planned man-made (cuts, fills, embankments, dams, etc.) whose failure, under any of the conditions to which they could be exposed during the life of a nuclear power plant or plants of specified type (or falling within a plant parameter envelope [PPE]) that might be constructed on the proposed site, could adversely affect the safety of the plant or plants. The following subjects should be evaluated using the applicant's data in the safety assessment and information available from other sources:

1. Slope characteristics (Subsection 2.5.5.1);

2. Design criteria and design analyses (Subsection 2.5.5.2) (needed at the combined operating license (COL) stage);

3. Results of the investigations including borings, shafts, pits, trenches, and laboratory tests (Subsection 2.5.5.3); and

4. Properties of borrow material, compaction and excavation specifications (Subsection 2.5.5.4) (needed at the COL stage).

The EMEB performs the following reviews under the review standard sections indicated:

1. The EMEB will determine the adequacy of the geologic and seismic information cited in support of the applicant's conclusions concerning the suitability of the plant site and the stability of earth and rock slopes as part of its primary review responsibility for Section 2.5.1 of NUREG-0800 (Ref. 1).

2. The EMEB reviews the seismological and geological investigations carried out to establish the ground motion environment for seismic design of a nuclear power plant or plants of specified type (or falling within a PPE) that might be constructed on the proposed site, the procedures and analysis used by the applicant in establishing the safe shutdown earthquake (SSE) for the site, as part of its primary review responsibility for Section 2.5.2 of NUREG-0800 (Ref. 2).

3. The EMEB reviews the results of the stability evaluations of earth and rock slopes to ensure that displacements or failure of site slopes as indicated in the safety assessment would not have an adverse impact on structural components.

II. ACCEPTANCE CRITERIA

The applicable rules and basic acceptance criteria pertinent to the areas of this section of the Review Standard are:

1. 10 CFR Part 50, Appendix A, General Design Criterion 44 - "Cooling Water." This criterion requires that a system shall be provided with the safety function of transferring the combined heat load from structures, systems, and components important to safety to an ultimate heat sink under normal operating and accident conditions. (Ref. 3)

2. 10 CFR Part 100, "Reactor Site Criteria." This part describes criteria which guide the evaluation of the suitability of proposed sites for nuclear power and testing reactors. (Ref. 4)

3. 10 CFR 100 .23, “Geologic and Seismic Siting Criteria.” These criteria describe the nature of the investigations required to obtain the geologic and seismic data necessary to determine site suitability and identifies geologic and seismic factors required to be taken into account in the siting and design of nuclear power plants. (Ref. 5)

If a reactor design is not specified, the ESP applicant may (instead of providing information on safety-related facilities or systems, structures, and components as called for in this section of this review standard) provide a PPE to characterize a facility or facilities for comparison with the geological, geotechnical and seismological characteristics of the site. A PPE can be developed for a single type of facility or a group of candidate facilities by selecting limiting values of parameters. Important PPE parameters for safety assessment Section 2.5 include, but are not limited to, SSE (e.g., peak ground acceleration, minimum soil shear wave velocity), site water level (e.g., maximum ground water level), and the soil properties design bases (e.g., minimum static bearing capacity and liquefaction).

Note: Though not required at the ESP stage, the COL applicant will need to demonstrate compliance with General Design Criterion 2 (Ref. 6) as it relates to structures, systems, and components important to safety being designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions.

The following regulatory guides provide information, recommendations, and guidance and in general describe a basis acceptable to the staff that may be used to implement the requirements of 10 CFR Part 50, Appendix A, General Design Criterion 44; 10 CFR Part 100; and 10 CFR 100.23.

1. Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants." This guide describes a basis acceptable to the staff that may be used to implement General Design Criterion 44 with regard to the ultimate heat sink, including necessary retaining structures and the canals and conduits connecting the ultimate heat sink with the cooling water system intake structures. (Ref. 7)

2. Regulatory Guide 1.198, “Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites.” This guide describes procedures and criteria acceptable to the staff for assessing the potential for earthquake-induced liquefaction of soils for the design of foundations and earthworks at nuclear power plant sites in accordance with 10 CFR Part 100. (Ref. 8)

3. Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants." This guide describes programs of site investigations related to geotechnical engineering aspects that would normally meet the needs for evaluating the safety of the site from the standpoint of the performance of foundation and earthworks under anticipated loading conditions, including earthquake, in complying with 10 CFR Part 100. It provides general guidance and recommendations for developing site-specific investigation programs as well as specific guidance for conducting subsurface investigations, the spacing and depth of borings, and sampling. (Ref. 9)

4. Regulatory Guide 1.138, "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants." This guide describes laboratory investigations and test practices acceptable for determining soil and rock properties and characteristics needed for engineering analysis and design for foundations and earthwork for nuclear power plants in complying with 10 CFR Part 100. (Ref. 10)

The information in the safety assessment should be in compliance with the criteria presented in References 3, 4, and 10. This section of the safety assessment is judged acceptable if the information presented is sufficient to demonstrate the dynamic and static stability of all slopes whose failure could adversely affect, directly or indirectly, safety-related structures of a nuclear power plant or plants of specified type (or falling within a PPE) that might be constructed on the proposed site or pose a hazard to the public. The emergency cooling water source is of particular interest with regard to slope stability (Refs. 3 and 6). The secondary source of emergency cooling water should survive an earthquake equal to ½ SSE and design basis flood. Completeness is determined by the ability to make an independent evaluation on the basis of information provided by the applicant.

Specific criteria necessary to meet the relevant requirements of the Commission regulations identified above are as follows:

Subsection 2.5.5.1. In meeting the requirements of References 3 and 4 and the regulatory positions contained in References 6 through 9, the discussion of slope characteristics is acceptable if the subsection includes:

1. Cross sections and profiles of the slope in sufficient quantity and detail to represent the slope conditions.

2. A summary and description of static and dynamic properties of the soil and rock expected to comprise seismic Category I embankment dams and their foundations, natural and cut slopes, and all soil or rock slopes whose stability would directly or indirectly affect safety-related and Category I facilities. The text should include a complete discussion of procedures used to estimate, from the available field and laboratory data, conservative soil properties and profiles to be used in the analysis.

3. A summary and description of groundwater, seepage, and high and low groundwater conditions.

Subsection 2.5.5.2. In meeting the requirements of Reference 4 and the regulatory positions of Reference 6, the discussion of design criteria and analyses (needed at the COL stage) is acceptable if the criteria for the stability and design of all seismic Category I slopes are described and valid static and dynamic analyses have been presented to demonstrate that there is an adequate margin of safety. A number of different methods of analysis are available in the literature.

To be acceptable, the static analyses and the dynamic analyses described below (which are necessary at the COL stage) should include calculations with different assumptions and methods of analysis to assess the following factors:

1. The uncertainties with regard to the shape of the slope, boundaries of the several types of soil within the slope and their properties, the forces acting on the slope, and pore pressures acting within the slope.

2. Failure surfaces corresponding to the lowest factor of safety.

3. The effect of the assumptions inherent in the method of analysis used.

4. Adverse conditions such as high water levels due to the probable maximum flood (PMF), sudden drawdown, or steady seepage at various levels. In general, safety factors related to the slope hazard are needed; however, actual values depend somewhat on the method of analysis, on the assumptions concerning the soil properties, on construction techniques, and on the range of material parameters.

To be acceptable, the dynamic analyses should account for the effect of cyclic motion of the earthquake on soil strength properties. Actual test data are needed for the in situ soils. As discussed above, the various parameters, such as geometry, soil strength, modeling method (location and number of elements (mesh) if a finite-element analysis is used), and hydrodynamic and pore pressure forces, should be varied to show that there is an adequate margin of safety (Refs. 11 and 12). Where liquefaction is possible, major dam foundation slopes and embankments should be analyzed by state-of-the-art finite-element or finite difference methods of analysis. Where there are liquefiable soils, changes in pore pressure due to cyclic loading should be considered in the analysis to assess not only the potential for liquefaction but also the effect of pore pressure increase on the stress-strain characteristic of the soil and the post-earthquake stability of the slopes.

Subsection 2.5.5.3. In meeting the requirements of Reference 4 and the regulatory positions of References 8 and 9, the applicant should describe the borings and soil testing carried out for slope stability studies and dam and dike analyses. The test data, which should meet the criteria set forth in Sections 2.5.1 and 2.5.4, could be presented in those sections and referenced in this subsection. Because dams, dikes, and natural or cut slopes are often remote from the main plant area, results of additional exploration, tests, and analyses for these areas should be presented in this subsection.

Subsection 2.5.5.4. In meeting the requirements of Reference 4 and the regulatory positions of References 7, 8, and 9, the applicant should describe the excavation, backfill, and borrow

material planned for any dams, dikes, and embankment slopes. Planned construction procedures and control of earthworks should be described at the COL stage. To be acceptable, the information should be given as discussed in Subsection 2.5.4.5. Some of this information could be presented in Subsection 2.5.4.5. Because dams, dikes, and other earthworks are often remote from the main seismic Category I structures, it is necessary to complete this information in this subsection.

The technical rationale for application of these acceptance criteria to reviewing the stability of slopes is discussed in the following paragraphs:

Compliance with 10 CFR Part 100 requires that the Commission evaluate the suitability of proposed sites for nuclear power and test reactors. Section 100.20(c) requires that physical characteristics (including seismology, meteorology, geology, and hydrology) be taken into account when determining each site's acceptability.

To satisfy the geotechnical engineering requirements of 10 CFR Part 100, the applicant's safety assessment should contain a discussion of embankment dams and their foundations, natural and cut slopes, and all soil or rock slopes for which a lack of stability could adversely affect safety-related structures, systems, or components. Subsection 2.5.5.1 provides cross sections and profiles of the slopes and a description of the static and dynamic properties of soils and rock used in the embankments. Groundwater and seepage conditions should also be described. Meeting this requirement provides assurance (a) that a nuclear power plant or plants that might be constructed at the site could be designed to withstand appropriately severe geologic, geotechnical, and seismic phenomena and (b) that, during normal operations or seismic events, the plant or plants would pose no undue risk to the public as a result of instability, deformation, and failure of embankment structures and earthworks.

The safety assessment should also contain a description of soil and rock characteristics and include static and dynamic analyses of all cuts, fills, embankments, dams, and other earthworks at or on the proposed site. This information will permit the staff to assess the acceptability of the proposed site and to determine the potential influence of these characteristics on the design of structures, systems, and components important to safety. Meeting these requirements provides assurance that structures, systems, and components important to safety for a nuclear power plant or plants of specified type (or falling within a PPE) that might be constructed on the proposed site could be designed to withstand appropriately severe static and dynamic loads.

In order to comply with 10 CFR 100.23, the geologic and seismic conditions at the proposed site should be considered during the siting and design of a nuclear power plant or plants. It describes the investigations needed to obtain the geologic and seismic data necessary to determine site suitability and to provide reasonable assurance that a nuclear power plant or plants of specified type (or falling within a PPE) could be constructed and operated at a proposed site without undue risk to the health and safety of the public with respect to those characteristics. Meeting these requirements helps provide assurance that structures, systems, and components of a nuclear power plant or plants of specified type (or falling within a PPE) that might be constructed at the proposed site could be designed to withstand the effects of seismic events, thereby minimizing the probability that a failure would initiate an accident or exacerbate the consequences of an accident.

III. REVIEW PROCEDURES

The review process is conducted in a similar manner and concurrent with that described in Sections 2.5.1 and 2.5.2 of NUREG-0800, and 2.5.4 of this review standard. The services of consultants may be used to aid the staff in geotechnical engineering evaluations regarding foundation engineering and slope stability analyses, particularly in the evaluation of safety-related and seismic Category I earthworks, earth and rock-fill dams, dikes, and reservoirs. Typical references used by the staff are listed in Subsection VI. (Refs. 13 through 22)

An acceptance review is conducted to determine if the provided information is complete as outlined in Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," (Ref. 10) and to judge whether or not the information presented is sufficient to permit an independent in-depth review and analysis of the safety of the proposed facility. After acceptance of the safety assessment, the results of site investigations such as borings, maps, logs of trenches, permeability test records, results of seismic investigations, laboratory test results, profiles, plot plans, and stability analyses are studied and cross-checked in considerable detail to determine whether or not the assumptions and analyses used in the design are conservative. The degree of conservatism needed depends upon the type of analysis used, the reliability of parameters considered in the slope stability analysis, the number of borings, the sampling program, the extent of the laboratory test program, and the resultant safety factor. In general, the applicable soil strength data should be conservatively selected for the various possible soil profiles and slope conditions. For lower safety factors, several soil profiles should be analyzed to ensure that reasonable ranges of soil properties have been considered. Other factors such as flood conditions, pore pressure effects, possible erosion of soils, and possible seismic amplification effects should be conservatively assessed.

The design criteria and analyses for earth structures that would bear significantly on the acceptability of the site are reviewed to ascertain that the techniques employed are appropriate and represent the present state-of-the-art. An independent analysis of the design of safety-related earth or rock-fill embankments that would bear significantly on the acceptability of the site may be performed by the staff's advisors or by the staff as deemed necessary. Consultants may also evaluate natural or cut slopes, as needed, on a case-by-case basis.

After completing the review, if the staff's conclusions are consistent with those reached by the applicant, these conclusions are summarized in the safety evaluation report (SER) or in a supplement to the SER. In the event that the applicant's investigation and design are not judged to be sufficiently conservative, a staff position is stated and the applicant is asked to further substantiate its position by additional investigations or monitoring to demonstrate that a failure of the slopes in question will not harm the safety functions of a nuclear power plant or plants of specified type (or falling within a PPE) that might be constructed at the proposed site, or to concur in the staff position.

Site subsurface investigations supporting the ESP application should be conducted to provide sufficient coverage of the site areas upon which all safety-related structures will be located, such that there is reasonable assurance that the actual site conditions, revealed during excavations or further soil borings, will be consistent with the site subsurface model developed to support the ESP application. The ESP will contain a license condition requiring the reporting of any information the ESP holder has identified as having a significant implication for public

health and safety or for common defense and security. The Commission will evaluate any such information reported and will take appropriate action.

All natural safety-related slopes are examined during at least one of the two site visits by the staff. Because excavated slopes or embankments are not usually constructed until after a COL has been granted, detailed as-built documentation of these slopes and embankments, as well as complete stability and safety analyses are necessary but not at the ESP stage.

Following is a brief description of the review procedures conducted by the staff in evaluating the slope stability aspects of nuclear power plant sites.

Subsection 2.5.5.1. Plot plans, cross sections, and profiles of all safety-related slopes in relation to the topography and physical properties of the underlying materials are reviewed and compared with exploratory records to ascertain that the most critical conditions have been addressed and that the characteristics of all slopes have been defined. The soil and rock test data are reviewed to ensure that there is sufficient relevant test data to verify the soil strength characteristics assumed for the slopes, dikes, and dams under analysis. The evaluation is to some extent a matter of engineering judgment; however, if the safety factors resulting from the analysis are not appropriate to the hazards posed by a slope failure and other than clearly conservative soil properties and profiles were used, the applicant should obtain additional data to verify its assumptions, or to show that, even if the worst possible conditions are assumed, there is an adequate margin of safety. With respect to seismic analysis, this Subsection and Subsection 2.5.5.2 are reviewed concurrently at the COL stage because different methods of analysis may involve different approximations, assumptions, and soil properties.

In addition to generic state-of-the-art literature, other potential sources of information are those containing design, construction, and performance records of natural slopes, excavation slopes, and dams that may have been constructed in the general vicinity of the site. Examples of such documents are design memoranda and construction reports regarding nearby projects of public agencies such as the U.S. Army Corps of Engineers, the Tennessee Valley Authority, the U.S. Navy, the U.S. Bureau of Reclamation, and private construction contractors or architect-engineers. (Refs. 15 through 20)

Subsection 2.5.5.2. The criteria, design techniques, and analyses are evaluated by the staff at the COL stage to ascertain that:

1. Appropriate state-of-the-art methods have been employed.

2. Conservative assumptions regarding soil and rock properties have been used in the design and analysis of slopes and embankments as discussed above in Subsection 2.5.5.1.

3. Appropriately conservative margins of safety have been incorporated in the design of structures.

The criteria and design methods used by the applicant are reviewed to ascertain that state-of-the-art techniques are being employed. The design analyses are reviewed to be sure that the most conservative failure approach has been used and that all adverse conditions to which the slope might be subjected have been considered. Such conditions include ground motions from the safe shutdown earthquake, settlement, cracking, flood or low-water

steady-state seepage, sudden drawdown of an adjacent reservoir, or a reasonable assumption of the possible simultaneous occurrence of two natural events such as an earthquake and flood. The review is also concerned with determining whether or not the soil and rock characteristics derived from the investigations described in Subsection 2.5.5.3 have been completely and conservatively incorporated into the design. When marginal factors of safety are indicated by the independent analyses performed by the staff and its consultants, additional substantiation and refinement is necessary or the applicant should use more conservative assumptions.

No single method of analysis is entirely acceptable for all stability assessments; thus, no single method of analysis can be recommended. Relevant manuals issued by public agencies (such as the U.S. Navy Department, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation) are often used in reviews to ascertain whether the analyses performed by the applicant are reasonable (Refs. 18, 20, 21, and 22). Many of the important interaction effects cannot be included in current analyses and should be treated in some approximate fashion. Engineering judgment is an important factor in the staff's review of the analyses and in assessing the adequacy of the resulting safety factors.

If the staff review indicates that questionable assumptions have been made by the applicant or some nonstandard or inappropriate method of analysis has been used, then the staff or its consultant may model the dam or slope in a manner which is more consistent with the data and perform an independent analysis employing both deterministic and probabilistic methods as appropriate.

Subsection 2.5.5.3. A comprehensive program of site investigations including borings, sampling, geophysical surveys, test pits, trenches, and laboratory and field testing should be carried out by the applicant to define the physical characteristics of all soil and rock beneath safety-related and seismic Category I slopes, and borrow material that is to be used to construct safety-related dams, fills, and embankments (Refs. 8 and 9). The staff reviews these investigations to ascertain that the program has been adequate to define the in situ and earthwork soil and rock characteristics. The decision as to the adequacy of the investigation program is based on the methods discussed in Section 2.5.4 of this review standard.

Subsection 2.5.5.4. The preliminary specifications and quality control techniques to be used during construction are reviewed by the staff at the COL stage to ascertain that all design conditions are likely to be met. During this part of the review the following are among those subjects reviewed for adequacy:

1. Proposed construction dewatering plan to ensure that it will not result in damage either to the natural or engineered foundation materials or to the structural foundation.

2. The excavation plan to remove all unsuitable materials from beneath the foundations and the quality control procedures which establish suitable materials.

3. The techniques and equipment to be used in compacting foundation and embankment materials.

4. The techniques for improving the stability of natural slopes such as drainage, grouting, rock bolting, and applying gunite.

5. The plans for monitoring during and after construction to detect occurrences that could detrimentally affect the facility. Such monitoring includes periodic examination of slopes, survey of settlement monuments, and measurements of local wells and piezometers.

IV. EVALUATION FINDINGS

Upon completion of the staff's review of the geotechnical engineering aspects of the material presented by the applicant related to the stability of all earth and rock slopes, both natural and manmade, an evaluation of completeness, accuracy and adequacy is made. If the evaluation confirms that the applicant has met the requirements and regulatory positions referenced in Section II above, the conclusion in the SER states that the investigations performed for slope stability studies and dam and dike analyses are adequate to justify the soil and rock characteristics that would be used in the design, and that the design analyses contain margins of safety which adequately demonstrate that natural and manmade slopes would remain stable under SSE conditions and that safety-related earthwork could be designed to function reliably.

The staff's conclusions regarding the stability of slopes are summarized in the safety evaluation report or in a supplement to the SER. The following is an example:

> Both natural and man-made slopes exist at the site. At the plant site, which is located several hundred meters (feet) from the Green Valley and about 85 meters (280 feet) above the level of Jones Pond, the slope is relatively gentle for about 75 meters (250 feet) west of the westernmost planned Category I structures, then steepens, attaining an angle of more than 45° near the bottom of the valley wall. Major structural trends, schistosity, and one of the predominant joint trends are nearly perpendicular to the slope. A second predominant joint set is nearly parallel to the river and dips to the southwest, but no slope movements have apparently affected the valley walls in the vicinity of the site. Seven other joint trends were detected by the applicant. These joint sets are reported to be moderately spaced and discontinuous. The applicant has drilled several exploratory holes and cored others to assess the natural slope characteristics and groundwater regime. Even though the natural slopes are some distance from planned safety-related plant facilities and slope failures are not obvious safety hazards, the applicant has performed stability analyses of these slopes under safe shutdown earthquake (SSE) conditions. The minimum computed safety factor was 1.6 using conservative slope and material parameters.
>
> Planned manmade earth slopes related to the safety of the nuclear power plant of type specified by the applicant that might be constructed on the proposed site include excavation cuts for the ultimate heat sink canal and dams and dikes for the ultimate heat sink storage pond. An extensive investigation and test program has determined all the significant characteristics and properties of cut slopes and fill embankments. Earthwork compaction criteria, construction control, and select fill materials are consistent with high-quality water-retention facilities. Conservative stability analyses of these slopes under SSE conditions indicated minimum safety factors of 1.5.

Based on the foregoing, the staff concludes that information including analysis and substantiation presented by the applicant is sufficient to demonstrate the dynamic and static stability of all slopes whose failure could adversely affect directly or indirectly safety-related structures of a nuclear power plant of the type specified by the applicant [or falling within the PPE submitted by the applicant] that might be constructed at the proposed site or pose a hazard to the public and meets the requirements of the pertinent Commission regulations (cite appropriate references).

Further, the applicant has met the requirements of the pertinent Commission regulations (cite appropriate references) with respect to slope characteristics; design criteria and design analyses; results of investigations including borings, shafts, pits, trenches, and laboratory tests; properties of borrow materials; and compaction and excavation specifications by meeting the regulatory position in Regulatory Guide (cite appropriate references) or by providing and meeting an alternative method to these regulatory positions that the staff has reviewed and found to be acceptable.

In summary, based on the results of the applicant's investigations, laboratory and field tests, analyses, and criteria for design and construction, the staff concludes that natural slopes would remain stable under SSE conditions , and that man-made slopes and safety-related earthworks could be designed and constructed to function reliably and to remain stable under SSE conditions in compliance with 10 CFR Part 100.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this section of this review standard.

This section will be used by the staff when performing safety evaluations of ESP applications submitted by applicants pursuant to 10 CFR Part 52 (Ref. 23). Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

VI. REFERENCES

1. U.S. NRC Standard Review Plan, Section 2.5.1, "Basic Geologic and Seismic Information," NUREG-0800, Rev. 3, March 1997.

2. U.S. NRC Standard Review Plan, Section 2.5.2, "Vibratory Ground Motion," NUREG-0800, Rev. 3, March 1997.

3. 10 CFR Part 50, Appendix A, General Design Criterion 44, "Cooling Water."

4. 10 CFR Part 100, "Reactor Site Criteria."

5. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

6. Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants."

7. Regulatory Guide 1.198, "Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plants."

8. Regulatory Guide 1.132, "Site Investigations for Foundations of Nuclear Power Plants."

9. Regulatory Guide 1.138, "Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants."

10. Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants."

11. H. Bolton Seed, K. L. Lee, I. M. Idriss, and F. Makdisi, "Analysis of the Slides in the San Fernando Dams During the Earthquake of February 9, 1971," Report No. EERC 73-2, Earthquake Engineering Research Center, University of California, Berkeley (1973).

12. M. Newmark, "Effects of Earthquakes on Dams and Embankments," Geotechnique, 15: 140-141; 156, 1969.

13. Earthquake Engineering Research Center, University of California, Berkeley.

14. Multi-disciplinary Center for Earthquake Engineering, State University of New York, Buffalo, NY.

15. Engineering Manual EM 1110-1-1804, "Geotechnical Investigations," U.S. Army Corps of Engineers, January 2001.

16. Engineering Manual EM 1110-2-1908, "Instrumentation of Earth and Rock Fill Dams," U.S. Army Corps of Engineers, June 1995.

17. Engineering Manual EM 1110-2-1906, "Laboratory Soil Testing," U.S. Army Corps of Engineers, August 1986.

18. Engineering Manual EM 1110-2-1902, "Engineering and Design- Stability of Earth and Rock-Fill Dams," U.S. Army Corps of Engineers, April 1970.

19. ASCE Conference on Stability and Performance of Slopes and Embankments II, Berkeley, CA. (1992).

20. Bureau of Reclamation, "Earth Manual," First Edition, U.S. Dept. of Interior (1968).

21. Corps of Engineers, "Procedures for Foundation Design of Buildings and Other Structures (Except Hydraulic Structures)," Tech. Report TM 5-818-1 (formerly EM 1110-345-147), Office of the Chief of Engineers, Dept. of the Army (1965).

22. Department of the Navy, "Soil Mechanics, Foundations, and Earth Structures," NAVFAC DM-7, March 1971.

23. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."